Ultra-structure, organization and Function of the Golgi Apparatus

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Ruhul Amin	@February 16, 2023 3:32 AM
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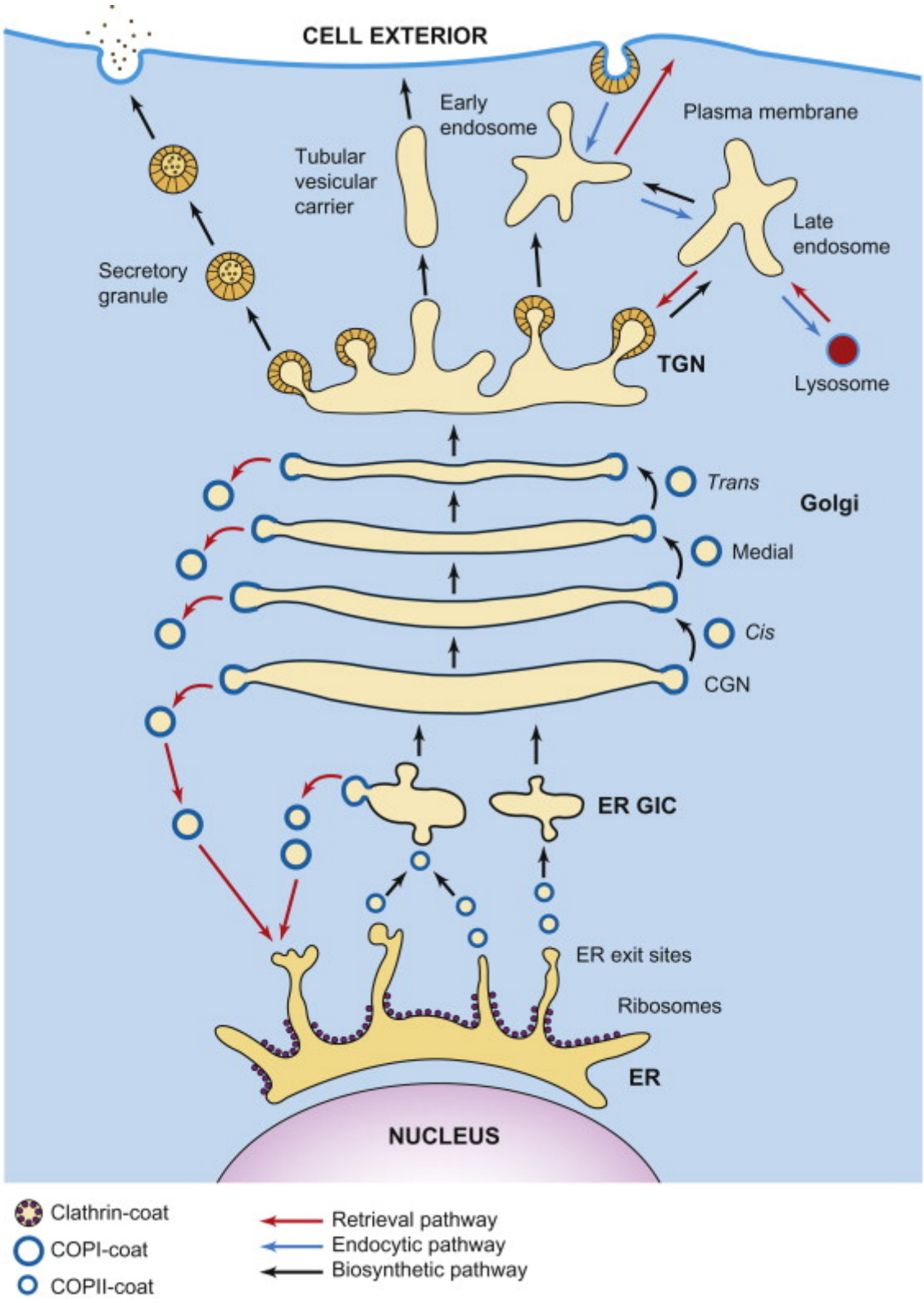
Golgi Apparatus: Introduction

- An organelle, consisting of layers of flattened sacs, that takes up and processes secretory and synthetic products from the endoplasmic reticulum and then either releases the finished products into various parts of the cell cytoplasm or secretes them to the outside of the cell. The Golgi complex is responsible inside the cell for packaging of the protein molecules before they are sent to their destination. This organelles helps in processing and packaging the macromolecules like proteins and lipids that are synthesized by the cell, sometimes referred as "post office" of the cell.

- Shape and size of Golgi complex is largely dependent upon type of cell and its physiological state. It is small in muscle cell but it is well developed in secretary cells. Further, it can be compact stack of fenestrated saccules or a diffuse network of lamellae.

Golgi Apparatus: Ultra-structure

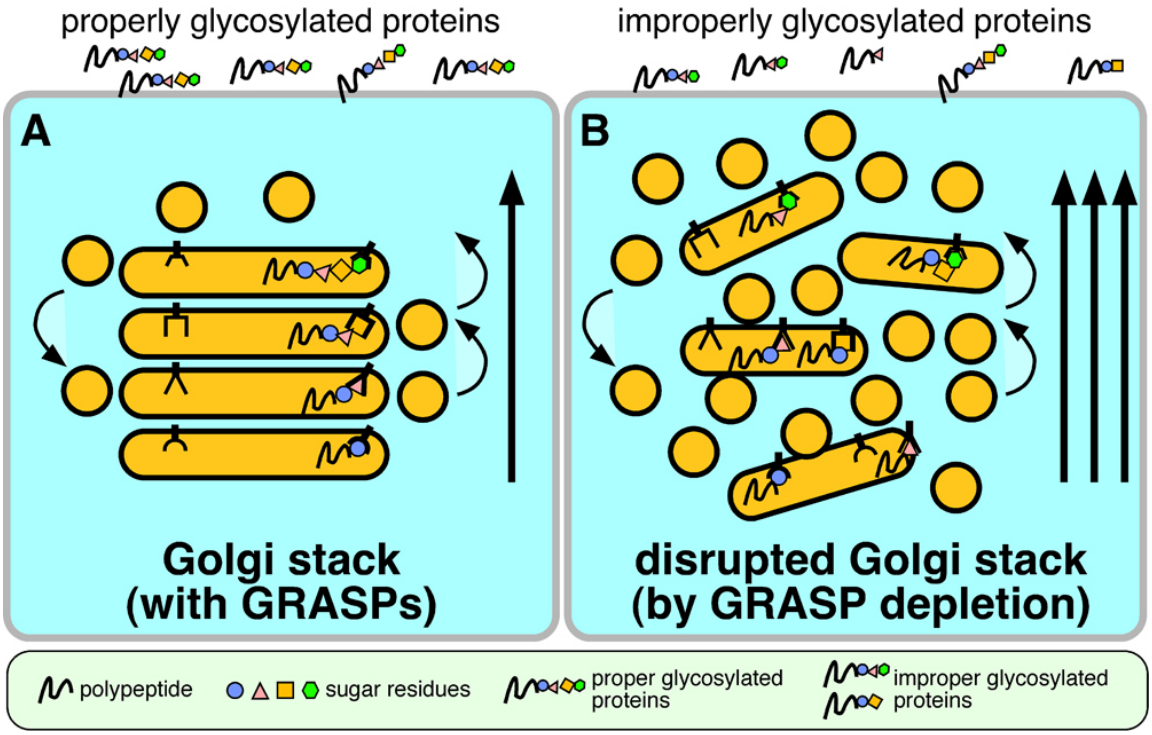
The Golgi apparatus, also known as the Golgi complex or Golgi body, is an organelle found in eukaryotic cells that is involved in the processing and modification of proteins and lipids synthesized in the endoplasmic reticulum.



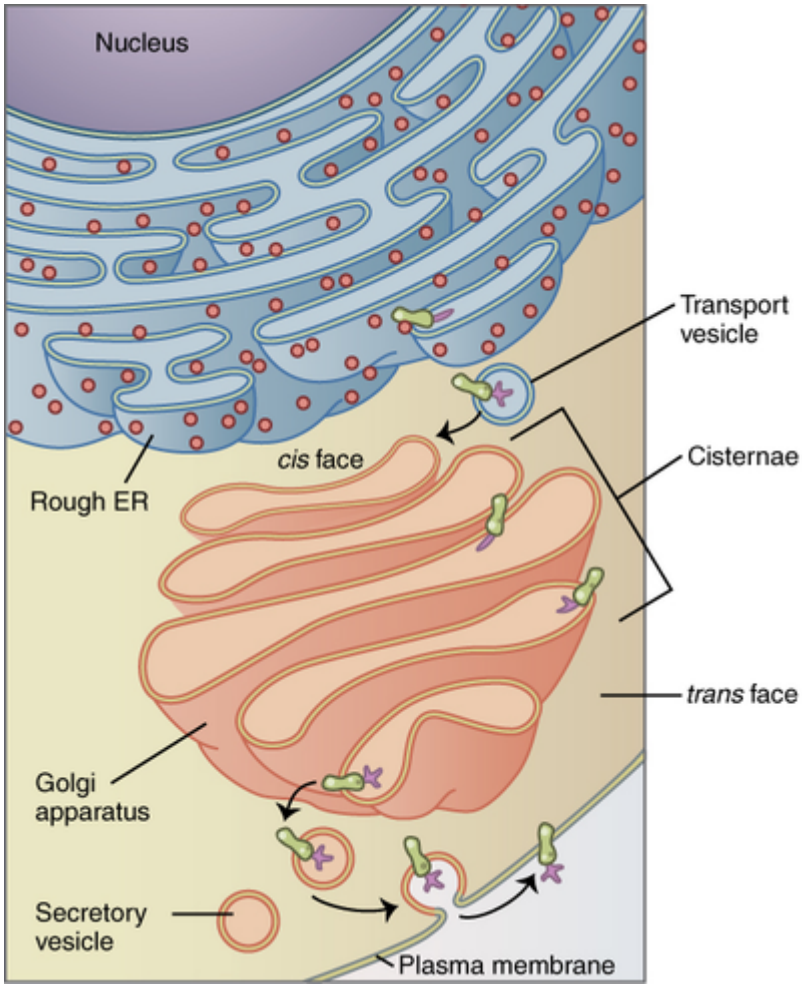
The Golgi apparatus is made up of several components, each with a specific function.

1. Golgi Stack:
   The Golgi stack is the collection of cisternae that make up the Golgi apparatus.

The stack is polarized, with the cis-Golgi network facing the endoplasmic reticulum and the trans-Golgi network facing the plasma membrane.



2. Cisternae:
   The Golgi apparatus is composed of flattened membrane-bound sacs called cisternae. These cisternae are stacked on top of each other, forming a series of flattened, curved plates. The cisternae can be further divided into three regions: the cis-Golgi network, the medial-Golgi, and the trans-Golgi network.



3. Dictyosome:

   An individual stack of the cisternae is sometimes referred as Dictyosome.

4. Golgi Matrix:
   The Golgi matrix is a proteinaceous scaffold that holds the cisternae in place. It is composed of several proteins, including golgins and GRASP (Golgi reassembly stacking protein) family members.

5. Golgi Enzymes:
   The Golgi apparatus contains a variety of enzymes that modify proteins and lipids as they pass through the cisternae. These enzymes include glycosyltransferases, which add sugar molecules to proteins and lipids; sulfotransferases, which add sulfate groups to proteins and lipids; and phosphotransferases, which add phosphate groups to proteins and lipids.

6. Golgi Lumen:
   The lumen of the Golgi apparatus is the space inside the cisternae. Proteins and

lipids pass through the lumen as they are modified and sorted by the Golgi enzymes.

7. Golgi-associated Coated Vesicles:
   Coated vesicles are vesicles that have a protein coat on their outer surface. The coat is made up of several proteins, including clathrin and COPI (coatomer protein I) and II. Golgi-associated coated vesicles are coated vesicles that bud off from the Golgi apparatus and transport proteins and lipids to other parts of the cell.
8. Vesicles:
   Vesicles are small, membrane-bound sacs that bud off from the Golgi apparatus and transport proteins and lipids to their final destination. There are two types of vesicles: transport vesicles and secretory vesicles. Transport vesicles carry proteins and lipids from the endoplasmic reticulum to the Golgi apparatus, while secretory vesicles carry proteins and lipids from the Golgi apparatus to their final destination.

Golgi Apparatus: Organisation

- The Golgi apparatus has a complex organization that is critical to its function.
- **The cis-Golgi network is the region of the Golgi stack that is closest to the endoplasmic reticulum. It is the site where newly synthesized proteins and lipids enter the Golgi apparatus. The medial-Golgi is the central region of the Golgi stack where most of the processing and modification of proteins and lipids occurs. The trans-Golgi network is the region of the Golgi stack that is closest to the plasma membrane. It is the site where proteins and lipids are sorted and packaged into vesicles for transport to their final destination.**
- The Golgi apparatus also contains a variety of enzymes that modify proteins and lipids as they pass through the cisternae. These enzymes include glycosyltransferases, which add sugar molecules to proteins and lipids; sulfotransferases, which add sulfate groups to proteins and lipids; and phosphotransferases, which add phosphate groups to proteins and lipids. The Golgi enzymes are organized in a spatially and temporally regulated manner to ensure that proteins and lipids are processed and modified in the correct order and at the correct location within the Golgi stack.

- In addition to its structural organization, the Golgi apparatus is also dynamic and constantly in motion. Vesicles constantly bud off from the Golgi stack and transport proteins and lipids to other parts of the cell. The Golgi stack itself is also constantly undergoing remodeling and reorganization, a process that is critical to its function.

Golgi Apparatus: Functions

The Golgi apparatus performs several functions, each of which is critical to its overall role in cellular metabolism.

1. Protein Sorting and Packaging:
   One of the primary functions of the Golgi apparatus is to sort and package proteins for transport to their final destination within the cell. The Golgi receives newly synthesized proteins from the endoplasmic reticulum and sorts them into different vesicles based on their ultimate destination. For example, some proteins are targeted for the plasma membrane, while others are targeted for lysosomes or other organelles. The Golgi also modifies these proteins by adding or removing carbohydrate groups, lipids, or phosphate groups, a process that is essential for proper protein function and localization.
2. Lipid Modification and Sorting:
   The Golgi apparatus is also involved in the modification and sorting of lipids synthesized in the endoplasmic reticulum. Like proteins, lipids are modified by the addition or removal of carbohydrate groups or other chemical moieties. The Golgi also sorts these lipids into different vesicles based on their ultimate destination. For example, some lipids are targeted for incorporation into the plasma membrane, while others are targeted for storage in lipid droplets.
3. Glycosylation:
   Another important function of the Golgi apparatus is the addition of carbohydrate groups to proteins and lipids. This process, known as glycosylation, is critical for proper protein folding, stability, and function. The Golgi contains a variety of glycosyltransferases, which add different types of carbohydrate groups to proteins and lipids. The Golgi is also responsible for modifying and trimming these carbohydrate groups, a process that is critical for proper glycoprotein function.
4. Processing and Modification:
   The Golgi is also involved in the processing and modification of proteins and lipids. This includes the addition of phosphate groups, sulfation, and the

modification of lipid molecules. The Golgi contains a variety of enzymes that are responsible for these modifications, including kinases, sulfotransferases, and phosphotransferases.

5. Vesicle Formation:
   The Golgi apparatus is also responsible for the formation of transport vesicles that carry proteins and lipids to their final destination within the cell. These vesicles bud off from the Golgi and are targeted to specific regions of the cell, where they release their cargo.
6. It is involved in the formation of **lysosomes and other enzyme-containing cellular inclusions**, and in the formation of secretory granules in cells such as those found in the pancreas, pituitary and mammary glands, and mucous-secreting glands of the intestine and in many other cell types
7. **Sulfation** process of certain molecules is an important task carried out by the Golgi body. The sulfating of substances passing through the lumen of Golgi body is carried out with the help of sulfotransferases.
8. Golgi apparatus plays an important role in the prevention of destruction of cells (or **apoptosis**). The Bcl-2 genes present in the Golgi are used for this purpose.

Functions (Secretion) of Golgi complex in different types of cells

S.No.	Cell Type	Golgi body Functions
1	Plant cells	Secretion of protein and cellulose.
2	Exocrine cells of Pancreas	Secretion of Zymogen (Digestive enzymes-protease, lipase)
3	Goblet cells of intestinal mucosa	Secretion of mucus and Zymogens
4	Paneth cells of intestine	Secretion of proteins
5	Brunner's gland cell or duodenum and ileum	Secretion of mucopolysaccharides (Glycosaminoglycan)
6	Hepatic cells of liver	Transformation and secretion of lipids
7	Follicle cells of thyroid gland	Prothyroglobulins
8	Plasma cells of blood	Immunoglobulins
9	Cells of alveolar epithelium (mammary glands)	Secretion of milk proteins

Golgi Apparatus From NCERT : For NEET Aspirants & Basics

- Camillo Golgi (1898) first observed densely stained reticular structures near the nucleus. These were later named Golgi bodies after him.
- They consist of many flat, disc-shaped sacs or cisternae of 0.5µm to 1.0µm diameter (Figure 8.6).

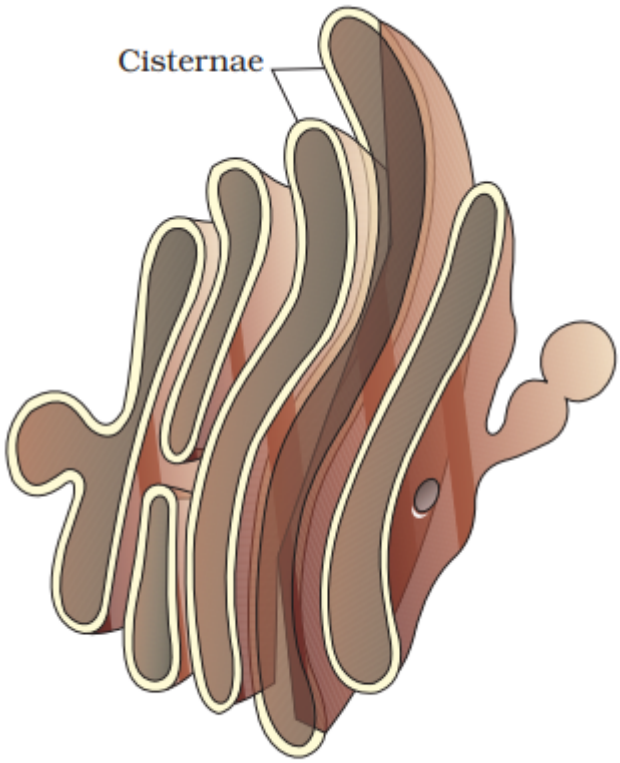


Figure 8.6 Golgi apparatus

- These are stacked parallel to each other.
- Varied number ofcisternae are present in a Golgi complex.
- The Golgi cisternae are concentrically arranged near the nucleus with distinct convex cis or the forming face and concave trans or the maturing face.
- The cis and the trans faces of the organelle are entirely different, but interconnected.
- The golgi apparatus principally performs the function of packaging materials, to be delivered either to the intra-cellular targets or secreted outside the cell.
- Materials to be packaged in the form of vesicles from the ER fuse with the cis face of the golgi apparatus and move towards the maturing face. This explains, why the golgi apparatus remains inclose association with the endoplasmic reticulum.

- A number of proteins synthesised by ribosomes on the endoplasmic reticulum are modifiedin the cisternae of the golgi apparatus before they are released from its trans face.
- Golgi apparatus is the important site of formation of glycoproteins and glycolipids.
- Cells at the end of prophase, when viewed under the microscope, do not show golgi complexes, endoplasmic reticulum, nucleolus and the nuclear envelope.
- Nucleolus, golgi complex and ER reform in telophase.

❓ How does the Golgi apparatus contribute to the formation and maturation of lysosomes?

The Golgi apparatus plays a critical role in the formation and maturation of lysosomes. Proteins that are targeted for lysosomal degradation are transported to the Golgi from the endoplasmic reticulum (ER) and are modified with specific carbohydrate and lipid residues by the Golgi enzymes. These modified proteins are then sorted and directed to the trans-Golgi network (TGN) where they are packaged into vesicles that will eventually form lysosomes. The vesicles containing the lysosomal proteins are then transported to the endosomes, which then mature into lysosomes. This process is called maturation by endosome-lysosome pathway. The lysosomes are now ready to degrade the molecules that will be delivered to them.